Predator Investigation
2004

Prepared for:

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Predators of bay scallops are abundant throughout Nantucket Harbor. A variety of these species are native, however invasive species are becoming more common. A preliminary sampling investigation on the numbers and identities of these predators was initiated in the summer of 2003. The intent was to obtain data that would warrant further studies, and possibly a control program. Background research and observations have also been conducted to obtain a better understanding on the ecological relationships these predators have with the bay scallop (*Argopectan irradians*), of commercial importance.

Sampling procedures during the summer of 2003 attempted to cover a majority of the harbor utilizing 12 crab pots to test various sites for the presence, and abundance of predators. These semi-oval fish traps, 26" x 19" x 9", have two round doors 4 3/4" that let fish and crabs in, but prevent them from exiting with a tapered mesh funnel directed towards the center of the trap. The pots were deployed mid summer, and were sampled weekly when time allowed. The pots were set initially without bait, and were catching crabs and fish right away because of the mobility of most crab and fish species. Green and asian crabs were culled out and used for bait after each sampling. When these invasive species were not present a single spider crab was used for baiting.

The results from the 2003 sampling indicated that the harbor contained a healthy diversified population of crab species. There were blue, spider, red, rock, lady, green, asian, hermit, and mud crabs present. Other predators of bay scallops included oyster toadfish, cunner, tautaug, and conch, which were also caught in the pots (note data sheet). These fish were released after each sampling. This diversity would imply that most, if not all ecological niches were being filled and utilized. Of special interest were the invasive green and asian crabs. The green crabs are believed to have arrived from Europe in the late 1800s, most likely in the ballast of commercial shipping (Van Heertum 2002). The more recently introduced asian shore crab was first seen in New Jersey in 1988 (Richerson 2003). At first it was called the purple shore crab, and also most likely arrived as a result of shipping.

A notable finding made during this investigation, was that these two introduced species were limited in presence to the lower harbor (note data sheet and graph). This data also shows that the green and asian crabs were the minority of the crab species in the harbor. Very few were caught, anywhere other than at the boathouse, and in the area of the Monomoy piers. This localization may be due to these crabs selected habitats, which are a result of their specific morphological characteristics. Their ideal natural and rocky habitat contains many cracks, crevasses, and jagged out croppings, that allow these crabs places to hide from larger predators of their own. These habitats are similar enough to the many piers, docks, and moorings in the lower harbor, where a man made niche has been created. However the rest of the harbor has a sandy, partially muddy bottom that is in most places covered with eelgrass and other algae. These invaders are now competing for food and space with the native species naturally occurring in those areas.

During the summer of 2004 a selected interest was taken concerning the green and asian shore crab. Noted for their aggressive behavior and voracious appetite, these crabs have larger and stronger crushing claws than most native crabs. This allows them to prey on larger scallop seed, creating a greater threat than many of the native species. This results in upsetting the natural food web. The recent introduction of these invasive predators, has not allowed the bay scallop thousands of years to develop evolutionary traits that would help them to detect and escape predation. The electrochemical signature of the invader, unknown to the scallop, gives the invader a greater advantage of predation over the native crab species. Prior to the invasion, a scallop would detect and possibly elude a native predator before they were in striking distance. The scallops are now possibly caught off guard by the invaders. Evidence of this was witnessed by (Estabrooks 2000), while conducting his summer classes at the Boathouse. There they documented a natural avoidance in scallops to native predators, but not the invasive. The native predator or its crushed remains were introduced into a large tank with scallops present. Immediately following this introduction the scallops moved away in opposing directions. However the bay scallop made no such recognition of the green crab when placed in the same experimental situations. This ability of the green crab to avoid detection has undoubtedly resulted in a negative impact to the bay scallop population. This may also contribute to greater mortality rates incurred throughout the summer on seed scallops. As opposed to the fall sets when the crabs are less active, due to the declining water temperatures.

In an attempt to minimize the predation impact, the 2004 investigation centered on a culling program of these invaders localized in the Monomy area where they were most prevalent, as seen in the 2003 sampling (note data sheet and graphs). The native species of crabs were returned to the water, except when occasionally used for bait. The belief is that the native population of crabs actually strengthens the scallop population by culling out the weak, injured, and less healthy individuals. Studies in Maine by (Leonard 1999) show that the presence of crab species directly induces the genetic potential of blue mussel (*Mytilus edulis*) towards the thickening of their shells. This "phenotypic plasticity" is directly related to predation in that mussels open less frequently with predators in close proximity. Genetically blue mussels and other shellfish have the ability to thicken their shells, but may not if predators are not present. This is important, because the lack of use of a genetic trait may result in loss of that trait over time. This then may result in the decline of a species as a result of the loss of a certain phenotype. Leonard also showed that direct contact was not needed, and that the mussels responded similarly to the presence of the feces of the crabs, and the crushed remains of other mussels as a result of predation.

A 30 gallon fish tank containing various crab, and shellfish species was set up for observation in the biologist's office in the fall of 2004. Observations were made on the spatial relationships between spider, mud, and asian crabs, and their successful or unsuccessful predation on scallops of various size, age, and health ranges. Oysters, mussels, and quahogs were also placed in the tank to determine the effectiveness of their defenses verses the scallop. Shrimp pellets were placed in the tank daily during the week so as not to starve the crabs, and increase their level of predation. The thinking here is that in the wild they would be feeding on dead fish, detritus, and other decaying matter, and not just shellfish. The filtration unit was intermittently removed from the filter, which was left on to circulate the water and various particulate maters. This allowed for the growth of algae, and the production of phytoplankton, so as not to starve the shellfish. An air pump and stone were also used to increase dissolved oxygen, and circulation. The water was changed regularly, and monitored for ammonia, and pH levels. A YSI 85 was also used to monitor salinity, and dissolved oxygen content, and a heater was used to maintain water temperature at 70° F.

These experimental procedures were basic, and performed only as time allowed, so the integrity of the experiment was not absolute. Despite this, many key observations were made by eye concerning the dynamic interactions of these species. These actions would otherwise have taken countless hours of diving to witness, or serendipitously catch at random with video monitoring. Scallops greater than 20mm in size and in good physical condition showed substantial resistance to the two spider crabs (carapace width 35mm). However when an asian crab (carapace width 30mm) was introduced, scallops as large as 35mm were quickly predated upon. A nub scallop with a ring at 17mm, and a total shell height of 58mm was relatively impervious for over two months under these abnormal conditions. For the most part this nub was undisturbed by the crabs, as if they sensed it would be wasted effort to attack it. Conversely, scallops that had been stranded by a receding tide, or washed about in the shallows and showing gill damage were immediately set upon. Even the relatively small mud crabs attacked these weak and ailing scallops relentlessly, devouring them within hours of being placed in the tank. The mud crabs also were witnessed breaking down the actual shell, possibly deriving some nutrients from this resource, or the algae growing on the shell. The selection of scallops and other shellfish preyed upon appears to be very deliberate, and calculated.

Crab species appear to be more scavengers than predators, and as such offer an invaluable service to the recycling of biological matter that would otherwise foul an ecosystem. Not only do they clean up after the death of any particular shellfish species, but they also make those species stronger. Through predation of the weak and sick individuals they remove poor genetic traits from the species as a whole. This predation then induces "phenotypic plasticity" in other individuals, resulting in thicker shells. This creates heartier shellfish, capable of being dredged or raked without being crushed. If this were not the case, the scallop would potentially be destroyed during the collection process, devaluing the stock commercially. On top of their intrinsic value, crab species also fill a necessary niche in the food web. Throughout their life cycle they provide food for many other species of fish and birds.

Invasive species however break up the natural order. Green crabs in certain areas have been documented (Choromanski & Stiles 2001) decimating scallop populations. The asian crabs have not been studied closely enough to understand their full impact, but are thought to be more aggressive and destructive than the green crab. It would be beneficial to continue a culling program of these invaders. However not all crab species should be considered a nuisance and eliminated similarly. If the native species were culled, their absence would open up more space for the invasive species. This has been seen in observations made on spatial distribution and competition, (Biologist's office tank 2004) where spider crabs are able to maintain territory in spite of the introduction of asian crabs. The asian crabs did compete for space amongst themselves, where two smaller asian crabs (13mm, and 17mm carapace width) were found on the office floor one morning. Presumably the larger asian crab had forced out the smaller two by way of the air hose during their predominantly nocturnal activities.

A large scale culling program or an overall loss in predators in the system would undoubtedly create another imbalance, and ultimately have a negative impact on the scallop population. So a continuation of a culling program would be recommended so long as it did not include the native species of crabs in Nantucket Harbor. Occasionally crab pots should be distributed around the harbor, as in 2003 to sample the distribution of the invaders. This would create some base line data that could follow trends and note changes, such as to the success of the program or the need for more control. The data collected, the observations made, and the research done by other scientists corroborates these conclusions.

References:

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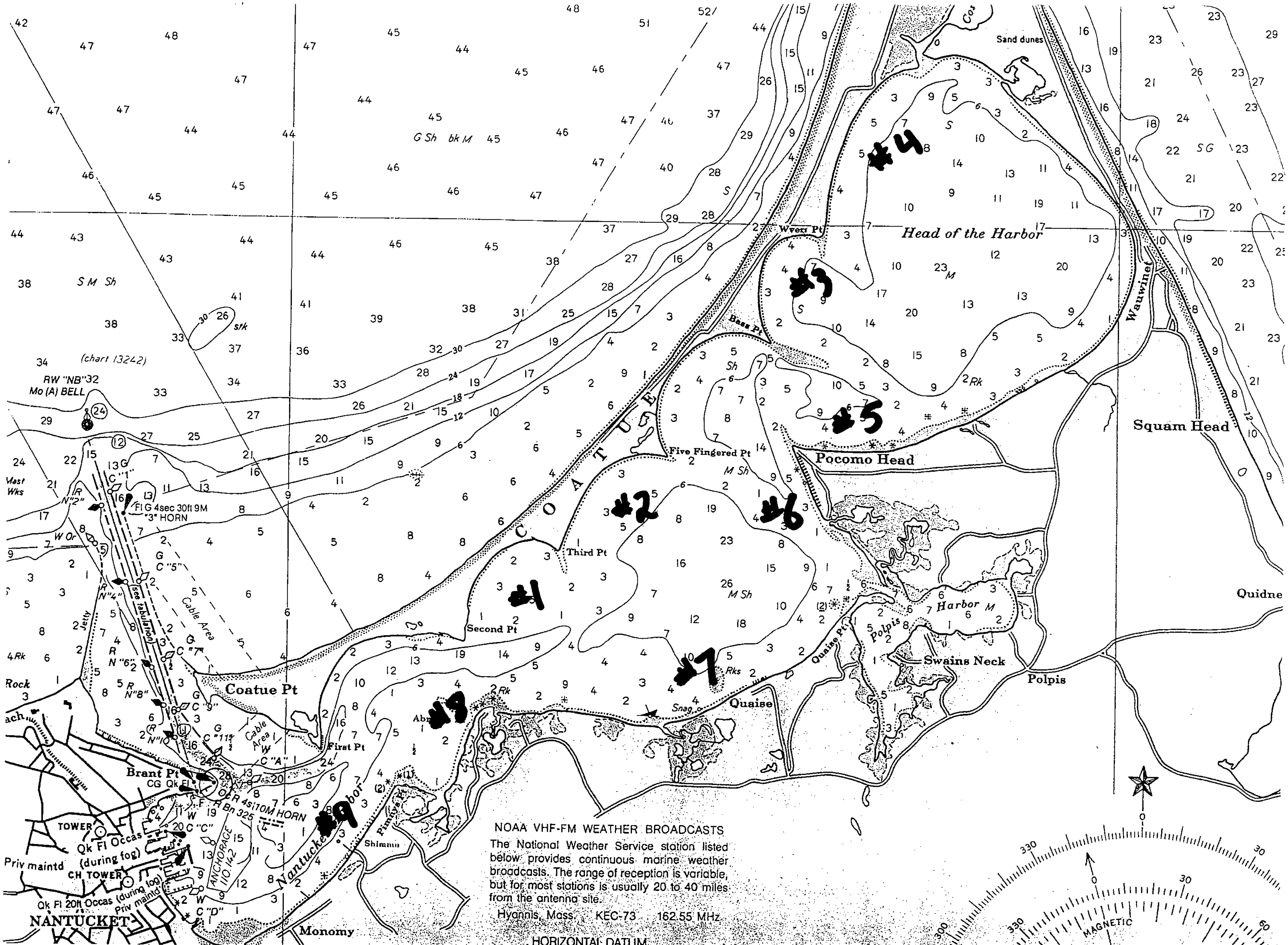
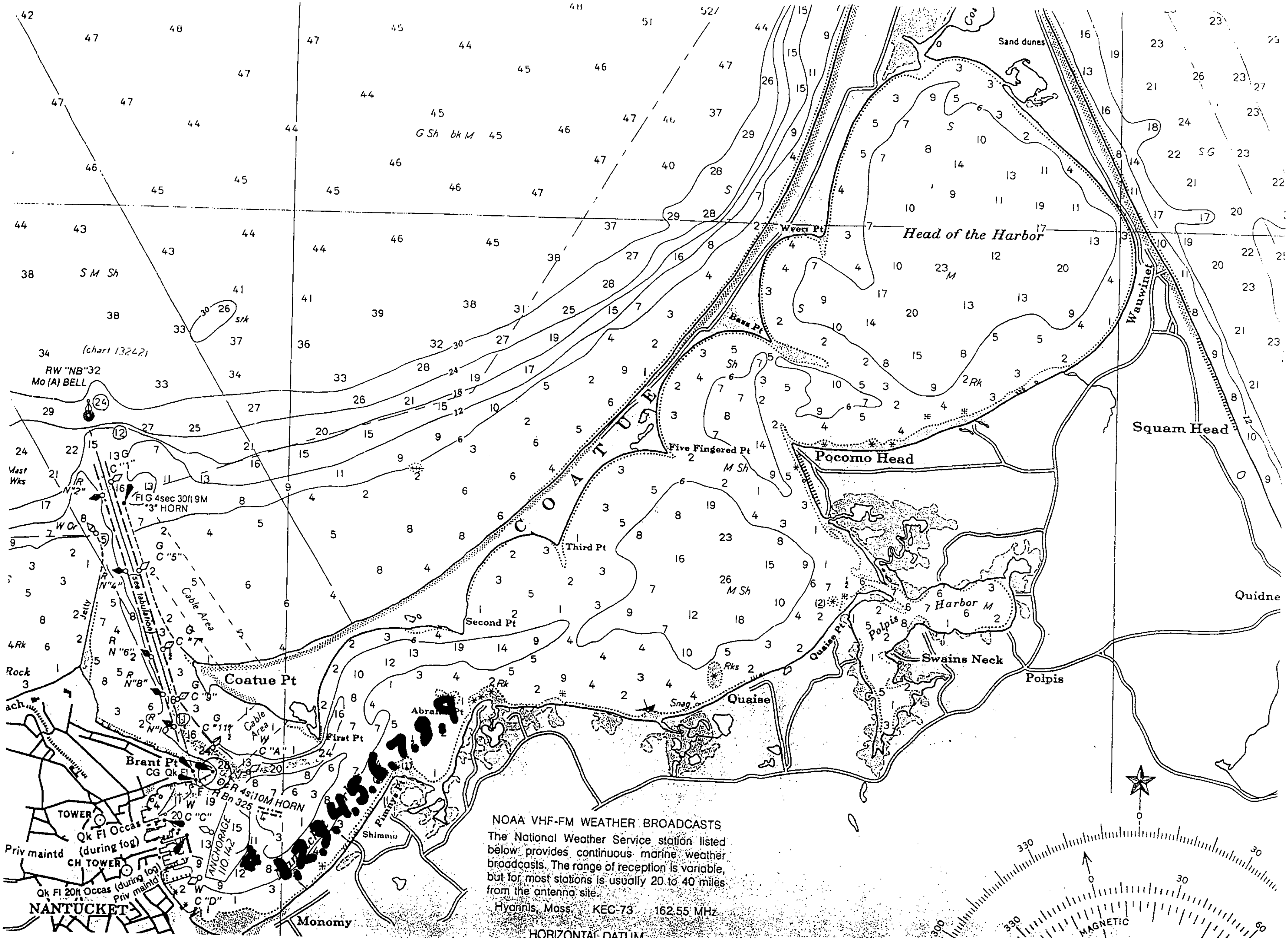
Richerson, M.M. 2003. *Hemigrapsus sanguineus* . USGS Nonindigenous Aquatic Species Fact Sheet. *USGS Database, Gainesville FL.* ID 183. 3p.

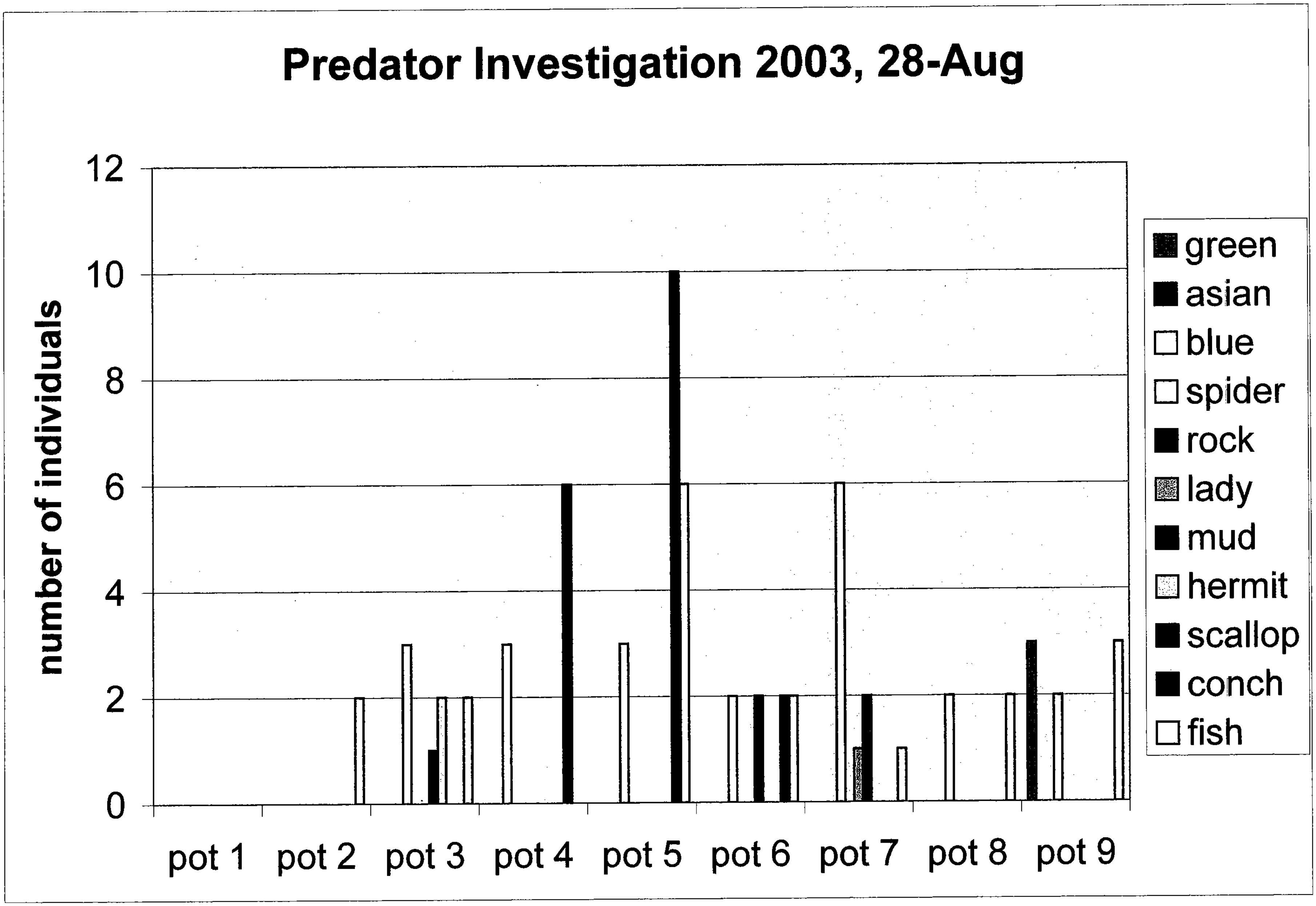
Van Heertum, R.2002. Introduced species summary project, European green crab (*Carcinus maenas*). *Invasion biology introduced species summary project – Columbia University.* 3p.

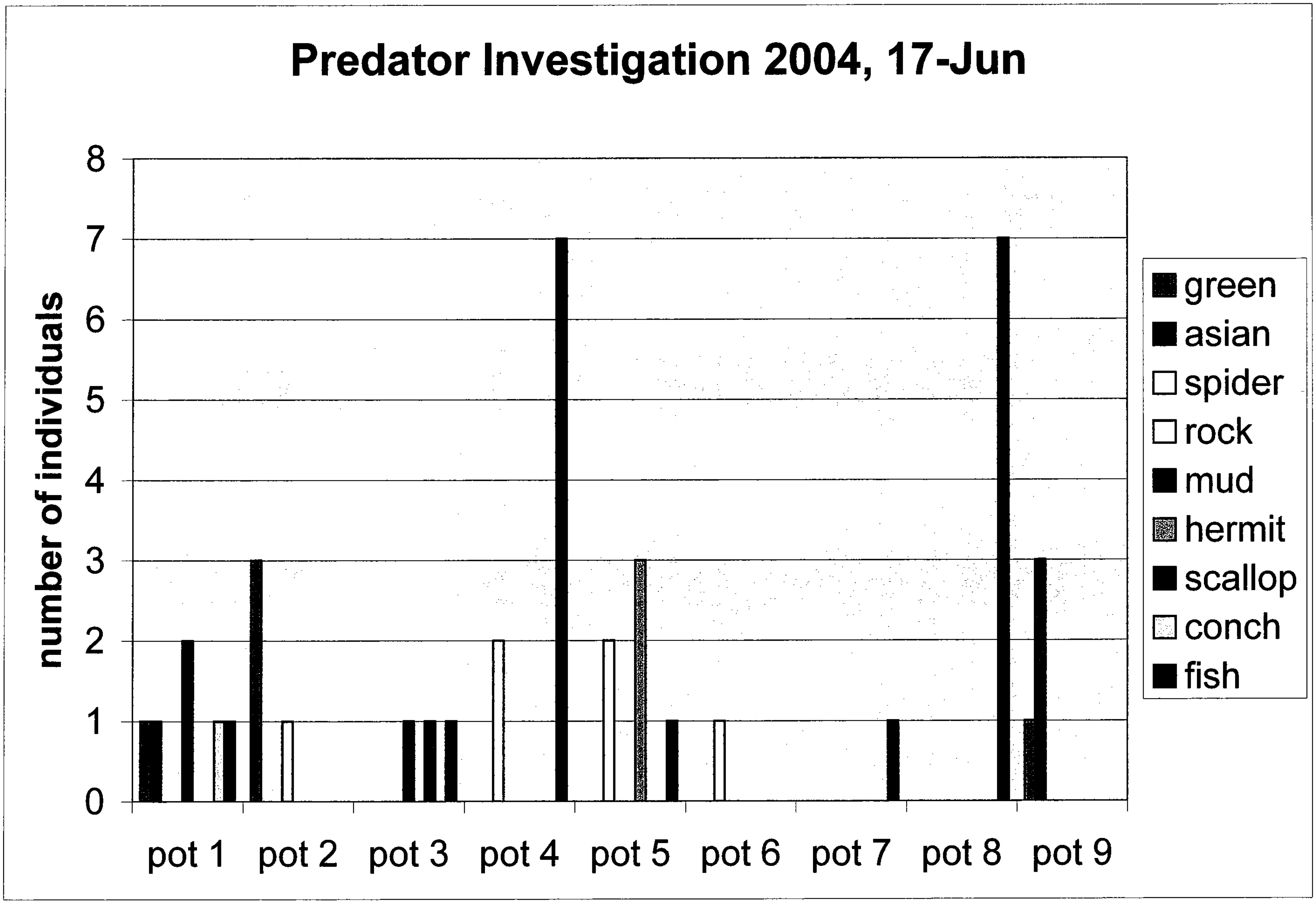


Map #1 Predator Investigation, 2003



Map # 2 Predetor Investigation, 2004


Predator Investigation 2003, 28-Aug
number of individuals
0
2
4
6
8
10
12
pot 1
pot 2
pot 3
pot 4
pot 5
pot 6
pot 7
pot 8
pot 9
green
asian
blue
spider
rock
lady
mud
hermit
scallop
conch
fish



Predator Investigation 2004, 17-Jun
number of individuals
0
1
2
3
4
5
6
7
8
pot 1
pot 2
pot 3
pot 4
pot 5
pot 6
pot 7
pot 8
pot 9
green
asian
spider
rock
mud
hermit
scallop
conch
fish

Predator Investigation 2003

Map #1,	2nd bend	3rd bend	5th bend	6th bend	Poc East	Poc West	UMASS	Abra' Pt.	Monomoy
28-Aug									
	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green	missing								3
asian									
blue				3					
spider			3		3	2	6	2	2
rock									
lady							1		
mud			1			2	2		
hermit			2						
scallop									
conch				6	10	2			
fish		2	2		6	2	1	2	3

Map #1,	2nd bend	3rd bend	5th bend	6th bend	Poc East	Poc West	UMASS	Abra' Pt.	Monomoy
3-Sep									
	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green	cage							missing	1
asian	open								
blue									
spider		3	1	13		1			
rock									
lady									
mud	1	1	7	1	3	2	4		2
hermit									
scallop		1	1				1		1
conch			1	5	1	1			
fish		2	1	1	2	5	1		1

Some data missing

Predator Investigation 2004

Map #2, pots 1-9 were located along the Monomoy shore line, starting near the first pier, then running north east to Abrahm's Pt.

10-Jun

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green	2								
asian									
spider	3	1					1		
rock		1							4
mud	2			8		1	2		
hermit	2				5				
scallop			4			1			
conch									
fish	2	1		2	6	9	3	1	3

17-Jun

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green	1	3							1
asian	1								3
spider				2	2	1			
rock		1							
mud	2		1						
hermit					3				
scallop			1						
conch	1								
fish	1		1	7	1		1	7	

24-Jun

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green									not
asian		1							sampled
spider	1	2	1		2				
rock									
mud	2			2					
hermit				3		1			
scallop									
conch					1				
fish			2			2	1`	2	

2-Jul

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green	2		open				open	missing	not
asian		1	empty			4	empty		sampled
spider	2	3		5	5				
rock									
mud		1				1			
hermit	17	1		1	1				
scallop									
conch	1								
fish	1	2		6					

8-Jul

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green					open				not
asian									sampled
spider	4	6	2	2		2	1	1	
rock									
mud								2	
hermit									
scallop					1				
conch									
fish				3		1	2		

15-Jul

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9 not sampled
green									
asian									
spider	6	4	1	6	2		2	1	
rock									
mud	1			2				1	
hermit						1			
scallop									
conch									
fish				1			1		

22-Jul

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7 open empty	pot 8 open empty	pot 9 not sampled
green									
asian									
spider	2			3	2				
rock									
mud	2		1						
hermit				1		1			
scallop					1				
conch									
fish	1	3		7					

Pots Baited with Blue Fish

29-Jul

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green		1	open						not
asian			empty						sampled
spider	7	21		10	1	1	1	9	
rock									
lady	2							1	
mud				8		1			
hermit	4								
scallop					2	1			
conch									
fish	1			3			1		

2 scallops 1st yr. adults in the process of spawning, pot 5

6-Aug

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green	2	1			ripped	open	open		not
asian					empty	empty	empty		sampled
spider				1					
rock									
lady									
blue			1						
mud				5					
hermit	2								
scallop			1	1					
conch									
fish				3				1	

1 nub scallop in process of ripening with black / orange gonad, pot 4

13-Aug

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green	1	1	open		1		open		missing
asian									
spider	3	5		9	5	5		11	
rock									
lady									
blue									
mud				6	6				
hermit									
scallop									
conch									
fish	1	1		2	7				

19-Aug

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7	pot 8	pot 9
green									not
asian									sampled
spider			1	3	2		3	2	
rock									
lady									
blue	2				1	1			
mud				5					
hermit									
scallop									
conch									
fish	7	2		1					

26-Aug

	pot 1	pot 2	pot 3	pot 4	pot 5	pot 6	pot 7 open empty	pot 8	pot 9 not sampled
green									
asian									
spider	3	2	1	2	2	4			
rock									
lady									
blue		1							
mud		4		6	1				
hermit									
scallop									
conch									
fish			2		3			2	

2-Sep

	pot 1	pot 2	pot 3 ripped empty	pot 4 ripped empty	pot 5	pot 6	pot 7	pot 8 missing	pot 9 not sampled
green									
asian									
spider	17	4				3	8		
rock									
lady							1		
blue									
mud	2				1		1		
hermit	3								
scallop					1	1			
conch	1								
fish	2				1				

1st yr adult in the process of ripening with black / orange gonad